Light, Strong, Durable – Solutions for Efficient Composites Fabrication
Dow VORAFORCE™ Composite Systems
Made to Perform

Dow VORAFORCE™ polyurethane composite systems are the result of innovative research and development built on more than 100 years of experience. They are tailored to offer fast curing, exceptional thermo-mechanical properties and excellent compatibility with fiber reinforcements to help master complex challenges in multiple industries.

The VORAFORCE™ Advantage

Advanced composite solutions from Dow offer significant performance, efficient processing and cost advantages for the fabrication of strong, lightweight and durable composites as used in energy, construction, infrastructure and transportation industries.

VORAFORCE™ composite systems from Dow enable:
- Toughness and durability
- High-temperature resistance
- Efficient processing
- Good corrosion and chemical resistance
- Quality consistency
- Tailorability to customer needs

The Dow Advantage

VORAFORCE™ systems demonstrate the knowledge, experience and technology innovation Dow offers its composites customers. With offices and development centers located around the world, Dow can ensure regional technical and commercial support wherever you are, whenever you need it.

Solutions for Efficient Composites Fabrication

Dow VORAFORCE™ polyurethane composite systems represent one of the most robust portfolios in the industry, with formulated solutions for filament winding, pultrusion, structural and long fiber injection applications.

The entire VORAFORCE™ range is characterized by low volatile organic compound (VOC) emissions during production.

Dow’s Specialized VORAFORCE™ Composite Systems Portfolio Is Tailored to Customer Fabrication Needs:

<table>
<thead>
<tr>
<th>Fabrication Process</th>
<th>Polyurethane Systems</th>
</tr>
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<tbody>
<tr>
<td>Filament Winding</td>
<td>★</td>
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<tr>
<td>Pultrusion</td>
<td>★</td>
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<tr>
<td>Long Fiber Injection</td>
<td>★</td>
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<tr>
<td>RTM, SRIM</td>
<td>★</td>
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<tr>
<td>Spray Preg, Composite Spray</td>
<td>★</td>
</tr>
<tr>
<td>Reinforced RIM</td>
<td>★</td>
</tr>
</tbody>
</table>
Dow VORAFORCE™ TP Resin Technology for Pultrusion
The VORAFORCE™ TP series consists of formulated systems for pultrusion applications. The VORAFORCE™ TP series of solutions exhibit superior mechanical and thermal properties for a wide range of applications. These systems exhibit low viscosities for efficient fiber wet-out and excellent handling characteristics.

**Benefits**
- Corrosion resistance
- Enhanced polyurethane systems
- Lightweighting
- Excellent processing properties

**Infrastructure**

**Marine: Seawalls**
- Fabrication process: Pultrusion
- Reinforcement: Glass and carbon fibers
- Dow system: VORAFORCE™ TP 1200 series

**Construction**

**Shaped Building Profiles:**
- I-, O-, U-, Z-Shaped
- Fabrication process: Pultrusion
- Reinforcement: Glass and carbon fibers
- Dow system: VORAFORCE™ TP 200/1200 series

Dow VORAFORCE™ TL Resin Technology for Long Fiber Injection
The VORAFORCE™ TL series consists of formulated systems for long fiber injection applications. The properties of the VORAFORCE™ TL series systems exhibit a range of desirable characteristics depending on the end application.

**Typical Properties of VORAFORCE™ TL Formulated Systems**

<table>
<thead>
<tr>
<th>System</th>
<th>HP Cream Time (s)</th>
<th>HP Machine Gel Time(s)</th>
<th>Comp. Viscosity @ 25°C (cP)</th>
<th>Glass Fiber Content in Polymer</th>
<th>Impact Charpy @ 25°C (kJ/m²)</th>
<th>Tensile Strength (MPa)</th>
<th>Flexural Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VORAFORCE™ TL 1651/TL 1600</td>
<td>35-40</td>
<td>70-75</td>
<td>360/210</td>
<td>20</td>
<td>&gt;40</td>
<td>&gt;70</td>
<td>&gt;80</td>
</tr>
<tr>
<td>VORAFORCE™ TL 1652/TL 1600</td>
<td>40-45</td>
<td>60-65</td>
<td>2100/210</td>
<td>35</td>
<td>&gt;53</td>
<td>&gt;140</td>
<td>&gt;200</td>
</tr>
<tr>
<td>VORAFORCE™ TL 1653/TL 1601</td>
<td>55-60</td>
<td>65-70</td>
<td>2800/600</td>
<td>34</td>
<td>&gt;60</td>
<td>&gt;150</td>
<td>&gt;200</td>
</tr>
<tr>
<td>VORAFORCE™ TL 1654/TL 1600</td>
<td>40-50</td>
<td>70-80</td>
<td>17000/200</td>
<td>35</td>
<td>&gt;80</td>
<td>&gt;130</td>
<td>&gt;200</td>
</tr>
<tr>
<td>VORAFORCE™ TL 1655/TL 1600</td>
<td>45-50</td>
<td>55-60</td>
<td>2500/210</td>
<td>32</td>
<td>&gt;35</td>
<td>&gt;130</td>
<td>&gt;120</td>
</tr>
<tr>
<td>VORAFORCE™ TL 1658/TL 1602</td>
<td>90-100</td>
<td>160-170</td>
<td>2100/130</td>
<td>35</td>
<td>&gt;65</td>
<td>&gt;140</td>
<td>&gt;230</td>
</tr>
<tr>
<td>VORAFORCE™ TL 1659/TL 1602</td>
<td>90-100</td>
<td>160-170</td>
<td>2100/130</td>
<td>35</td>
<td>&gt;65</td>
<td>&gt;140</td>
<td>&gt;230</td>
</tr>
<tr>
<td>VORAFORCE™ TL 1660/TL 1600</td>
<td>35-40</td>
<td>65-70</td>
<td>1100/210</td>
<td>25</td>
<td>&gt;60</td>
<td>&gt;65</td>
<td>&gt;95</td>
</tr>
</tbody>
</table>

*Data per tests conducted by Dow. Test protocols and additional information available upon request. Properties shown are typical and not to be construed as specifications.*
Infrastructure

**Manhole Covers**
Fabrication process: Long fiber injection
Reinforcement: Chopped glass fiber
Dow system: VORAFORCE™ TL 1600 series

Urban infrastructure applications include composites bridges.

**Construction**

**Building Parts and Panels**
Fabrication process: Long fiber injection
Reinforcement: Chopped glass fibers
Dow system: VORAFORCE™ TL 1600 series

Applications:
- Cladding and roof panels
- Windows and doors
- Decking solutions

**Transportation**

**Vehicle Parts**
Fabrication process: Long fiber injection
Reinforcement: Chopped glass fibers
Dow system: VORAFORCE™ TL 1600 series

Applications:
- Vehicle body panels
- Dashboard reinforcements
- Fenders

**Benefits**
- Excellent processing properties
- Excellent load-bearing properties
- Short cycle times due to very fast cure
- Good surface quality
- Good chemical resistance

**Benefits**
- High strength and toughness
- Good durability and weatherability
- Very fast cure for short cycle

**Benefits**
- Excellent mechanical properties
- Very fast cure for short cycle times
- High structural strength composite parts
**Dow VORAFORCE™ TW Resin Technology for Filament Winding**

The VORAFORCE™ TW series consists of formulated systems for filament winding applications. They exhibit excellent flow properties and fiber wetting due to low viscosities and long working times. This system combines good mechanical and electrical properties, as well as high temperature resistance and low moisture take-up.

**Typical Properties of VORAFORCE™ TW Formulated Systems**

<table>
<thead>
<tr>
<th>System</th>
<th>Glass Transition Temp (°C)</th>
<th>Mix Ratio (phr)</th>
<th>Pot Life (min)</th>
<th>Mixed Viscosity @ 25°C (cPs)</th>
<th>Suggested Cure Schedule</th>
<th>Tensile Strength (MPa)</th>
<th>Flexural Strength (MPa)</th>
<th>K(_c) Fracture Toughness (MPa – m(0.5))</th>
</tr>
</thead>
<tbody>
<tr>
<td>VORAFORCE™ TW 1150/TW 1100</td>
<td>85-95</td>
<td>105</td>
<td>25-30</td>
<td>100-300</td>
<td>2 hrs @ 100°C</td>
<td>65-75</td>
<td>90-100</td>
<td>1.6-1.8</td>
</tr>
</tbody>
</table>

\(^1\)Data per tests conducted by Dow. Test protocols and additional information available upon request. Properties shown are typical and not to be construed as specifications.

**Infrastructure**

**Electrical: Power and Transmission Poles**

Fabrication process: Filament winding

Reinforcement: Continuous glass fibers

Dow system: VORAFORCE™ TW 1100 series

**Benefits**

- Continuous reinforcement and manufacture of cylindrical structures
- Enhanced elongation, toughness and crack resistance
- Solutions available for critical humidity manufacturing conditions (up to 60% relative humidity)

**Dow VORAFORCE™ TJ Resin Technology for Structural Applications**

The VORAFORCE™ TJ series consists of formulated systems for structural composite applications. These systems exhibit good mechanical properties for a wide range of applications.

**Typical Properties of VORAFORCE™ TJ Formulated Systems**

<table>
<thead>
<tr>
<th>System</th>
<th>HP Machine Cream Time (s)</th>
<th>HP Machine Gel Time (s)</th>
<th>Comp. Viscosity @ 25°C (cPs)</th>
<th>Hardness (Shore D)</th>
<th>Impact Charpy @ 25°C (kJ/m²)</th>
<th>Flexural Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VORAFORCE™ TJ 1852/TJ 1802/TM 3502</td>
<td>3-4</td>
<td>8-10</td>
<td>1250/250</td>
<td>75-80</td>
<td>30-35</td>
<td>85-90</td>
</tr>
</tbody>
</table>

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Transportation

**Vehicle Parts**
Fabrication process: Reinforced reaction injection molding (RRIM)
Reinforcement: Short mineral fibers
Dow system: VORAFORCE™ TJ 1800 series

Applications:
- Aesthetic interior parts
- Bumpers
- Mud guards

Benefits
- Enhance performance through toughened technology
- Low temperature impact resistance
- Superior surface quality
- Fast cure
- Excellent paintability

Technical and Design Parts

**Chair Shells**
Fabrication process: Reinforced reaction injection molding (RRIM)
Reinforcement: Short glass fibers or fillers
Dow system: VORAFORCE™ TJ 1800 series

Benefits
- High surface quality
- Short cycle times

Product Stewardship
When considering the use of any Dow products in a particular application, you should review the latest Material Safety Data Sheets from Dow and ensure that they are intended for safe use. For Material Safety Data Sheets and other product safety information, contact Dow. Before handling any other products mentioned in the text, you should obtain available product safety information and take necessary steps to ensure safety of use.

No chemical should be used as or in a food, drug, medical device or cosmetic, or in a product or process in which it may contact a food, drug, medical device or cosmetic until the user has determined the suitability and legality of the use. Since government regulations and use conditions are subject to change, it is the user’s responsibility to determine that this information is appropriate and suitable under current, applicable laws and regulations.

Dow requests that the customer read, understand, and comply with the information contained in this publication and the current Material Safety Data Sheet(s). The customer should furnish the information in this publication to its employees, contractors and customers, or any other users of the product(s), and request that they do the same.